on the Localization of Dissection Features in the Hills-a case of Mizusawa Hills

On the Localization of Dissection Features in the Hills

— a case of Mizusawa hills —

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A land surface is usually under subaerial denudation or erosion processes, and certain changes of nature of the surface are proceeding in various rates and forms.

Two major fluvial processes, erosion and deposition have a difference in respect to their working fields. Erosion as well as denudation is acting above a given base level of erosion, but deposition is in most cases below the level (Nakamura 1963, p. 90). This difference leads us to the following understanding.

As the base level is represented by certain water levels — sea, lake, river and so on—, the deposition goes on often in water. The depositional process which means the creation of a new landform is unable to be observed without some experimental equipments. The columnar sections of depositional landform make the process of landform building clear with the aid of sedimentological analysis.

On the other hand, erosional process goes on subaerially and the landform building, or destruction of an antecedent landform is performed in front of our eyes. Thus the erosional landform seems to be grasped more easily and precisely.

However, this merit has been less appreciated because the erosional landform is deprived of deposit materials by which we can clarify the sequence of landform evolution, the formation of depositional surface, and the environment of the field.

In spite of the lack of material evidence, erosional landform is still being formed and transformed into various kinds of land features, and, to the most importance, the erosional process is operating all over the land surface. Recent development of air-photo interpretation covers the shortage of method in study of erosional landforms. The writer has sought with increasing interest about erosional landforms especially on the distribution pattern of dissection features in these years. In this report an idea of localization of dissection features is presented on the viewpoint that a local variety in the distribution of erosive processes would be revealed according to the progress of landform evolution.

1 Problem setting—three types of landform evolution

In respect to landform changes, three types are recognized as follows.

1) Differential type — The initial landform as a unit of morphological uniform area transforms more or less gradually or abruptly into several units including the

reduced area of the initial form, and ultimately entirely different forms are brought about. On the way of transformation, changes of erosive power are not always necessary for the emergence of various kinds of landforms, because the locational conditions change according to the transformation. Geomorphic change inevitably affects the area with not only horizontal but also vertical extent. This type is shown in the following scheme.

$A \rightarrow A + B \rightarrow A + B + C \rightarrow B + C \rightarrow C + D + E \rightarrow \dots$

Example: In the case of terrace;

flat surface → flat surface + steep scarp → reduced flat part + scarp + valley plain→....

Fan, upland, etc. also follow this type of succession.

Consideration on this viewpoint results in morphogenetic understanding of the landforms, and is applicable to the studies of geomorphological development and morphological analysis.

2) Overlapping type — On the halfway of a landform evolution, often occurs an abrupt change in erosive agencies, hence there appears an overlapping of younger landform on the older one. Change or alternation in geomorphic environment required the subordinate change of erosive power to adjust to the new circumstance. Of course, not only "overlapping" but also "peeling off" of the surface must take place, according to changes in erosion process. When a surface is buried beneath the younger deposits, it becomes a fossil topography. Where such covering has happened, the present landform is only a superficial cover which consists of a series of former landforms vertically overlapping. Thus the present figure of landform involves many historical evidences within its structure. To clarify the geomorphic structure, and to explain the geomorphic development of a region, the "stratigraphical" method must be adopted.

This change is displayed as a scheme as follows.

$A \rightarrow A\,(B) \rightarrow (A)\,B \rightarrow (A,B)\,C \rightarrow \dots$

Example: the terrace;

an initial terrace surface→terrace surface is covered with volcanic ash, marine sediments, etc.→superficially transforms into volcanic or marine landform→ uplifted and cut by streams or wave action→younger terrace or some other landforms....

This process needs a certain change in environment.

3) Compound type — This is a kind of a short cut or an abridgement of total sequence with some omissions.

$A \rightarrow A \times B = C\,;\, D \rightarrow D \times E = F; \dots$

Example: a terrace×dissection=hills; mountains×erosion for the long time=

peneplain, etc.

To deduce a morphological process judging from the facies in columnar sections of exposures is based upon this point of veiw. This method or viewpoint has been introduced too much into the analysis on chronological aspect in geomorphology. This understanding of geomorphology seems simple but involves some danger in precise recovering of geomorphic development. A chronological sequence can be arranged in this way so easily that somtimes the areal extent of geomorphic development is overlooked.

Although these methods are effective surely in many aspects of geomorphology, especially for depositional landforms, the writer sticks to method based on the first scheme, because the present figures, even if without any sedimentary material, change and evolve themselves under the present erosional processes. Erosional landforms have a vast room to be solved with effective approach. Fortunately photo-interpretation is more useful to the analysis of erosional landforms than of depositional landforms. The writer paid his attention on this merit and adopted the variations in valley forms as the most important element to understand the nature of erosional landforms.

2 Hills as a unit of erosional landform

1) An examination of terminology about hills

There are many landforms of small-relief and of densely or sparsely dissected features in Japan, and they are called "hills", "hill-land", or "hilly landforms". Here the expression about hill morphology is put in order and used as follows.

Hill is a single elevation with moderate relief against the surrounding plain. Dissecting valleys are hardly recognized on its slopes and a hill is not separated by valleys so that its typical shape is dome-like or a kind of mound. Of course it can be produced from several origins, and suffers subaerial erosion just like to mountain crest and slope.

Hills are an assemblage of individual hills, and in the same way mountains are of individual mountains. Hills have a remarkable extension in horizontal aspect, and they are a unit of geographical region. Hills are, on the other hand, a part of mountainous region or chief member of uplands. Hills are a complicated mosaic of various landforms, which involve terraces, valley plains, alluvial fans and cones, taluses, and erosional surfaces on the hill tops. Consequently various erosional and depositional processes cooperate and modify the landscape in the hills.

Hill-land or *hilly land* is used for explanation of nature (or characteristic) of a given area. This is useful in such a case as landfom division that requires an expression of optional region with aid of topographic term indicating a total landscape. Similar word like *hilly area* (*region, section, part,* etc.) is introduced as occasion demands.

Hill morphology denotes a geomorphological feature of hills, and it consists of two aspects; the morphology which is specific to the hilly region, and the one which is observed occasionally in hills, but is a common phenomenon in any landform evolution.

The writer will use the terms "hills", "hilly region" and "hill morphology" attached with limited meanings respectively.

2) Process of formation and deformation of hills

Any topographic element erosional or depositional can be the initial landform of hills, for examples, mountains, plateaux, terraces, and table-lands, if they have fine texture with active drainage systems. Most parts of hills are under erosive operations, so the hills are regarded as an erosional landform as a whole. Exceptions are the hills composed of sand dunes, debris flow mounds, or volcanic ejecta.

The formation of hills means the deformation of the initial landform, and the same deformation continues to destruct the hills, because denudation and erosion work without any interruption during the deformation of a given area. Though hills are seemingly a temporary form, they are significant and distinguishable elements in the landform evolution by reason of having many specific features.

Topographical surfaces of lowlands or plains are distributed mainly in horizontal dimension and their altitudinal ranges are relatively small, and their heights above the sea level can often be important criteria to correlate each surface. In the hilly regions, however, surfaces spread horizontally and vertically, in other words, in three dimensions. As the hills are erosional landforms, the valley development has a decisive influence in whole area of hills. There are three fundamental and two compound shapes in transverse profiles of valleys: *Muldental* (or concave-sloped valley), *Sohlen-kerbtal, Kerbtal* (or V-shaped valley); and *Kerbtal in Muldental, Sohlen-kerbtal in Muldental.*

Erosive agencies in these valleys are equal always and everywhere because the fluvial activity is controlled by the distribution of running water which is ruled under the shape of valley profile.

3) Formation of hilly regions in Tohoku

As the hills are erosional landforms, they are limited to the place with potential relief at least and under subaerial erosion in long time.

In Japan hilly regions are distributed in three cases as follows.

Uplifted and *dissected peneplains* have small relief and many small tributaries, which sculpture hills as parts of the peneplains. Small tributaries cut the older bedrocks, leaving a flat level upon the tops, and the remaining bodies are the hills.

At the northern and southwestern Kitakami mountains (Nakamura 1964, 1967) such hills are observed. The Abukuma mountains also have similar features at the central part where II and III planes (Nakamura 1969) are dissected densely with relatively low reliefs.

Tertiary sedimentary rock areas coincide with hilly regions (Nakagawa 1967). Hills in such areas have almost common features; that is, accordant height of hill tops, erosion surface-cutting the structure of Tertiary strata, closely spaced valleys in dissection, and different types of valleys.

Terrace surface utterly dissected is the third case. Terrace origin of hills is evidenced by the terrace gravels on the tops of hills,denoting a previous depositional surface. Hills of this origin were formed after the terrace forming period; as the most recent example, an artificial flat land which was built for the purpose to use as a residential or an industrial estate was dissected into hills in about 5 years (Nakamura 1960a).

Not only the Tertiary but also the Quaternary sediments can be the bedrocks for hill formation, and in such cases the hills are of gravels, sands, or younger deposits, and are in the lowland areas.

In Tohoku district there are all kinds of hills in their origin. It may be said that Tohoku presents us the best field for study of hill morphology. The hills in Tohoku are classified as shown in the table (cf. Nakagawa 1967, p. 372; Nakamura 1969b, p. 221).

3 Mizusawa hills

1) Situation and structure of the hills

On the "Mizusawa" quadrangle 1:50,000 a topographical division was carried out as a part of the Fundamental Land Classification Survey promoted by the Economic Planning Agency (Fujiwara, et al. 1963). The hilly sections in the quadrangle are picked up and briefly described (Fig. 1).

Geologically the hills are composed mainly of Neogene sandstone, mudstone, pumiceous tuff, dacitic tuff, etc. (Hanzawa 1954), which were the bedrocks underlying the past and present fluvial terraces.

The hills are grouped into two; the western hills along the foot of the Oou mountains, and the eastern ones at the western margin of Kitakami mountains. They are flat terraces in a few steps in origin, restored from the summit levels and gravels deposited on their preserved surfaces.

Table: Classification of the hills after their initial landform in Tohoku

Initial landform	Locality	Berdrocks	Altitude (m)
uplifted peneplain	Senmaya hills	Permian slate, granitic rocks	400-100
	Eastern area of Koriyama basin	granodiorite	500-300
erosion surface cutting the Tertiary strata	Sasamori hills	Miocene and Pliocene sand and mudstone	300-70
	Nonodake hills	Miocene and Pliocene sandstone, breccia, etc.	200-100
	Rikuzen hills	Pliocene tuffaceous standstone	150-60
	Kakuda hills	granite, Miocene tuffaceous shale	390-120
fluvial and marine terrace	Mizusawa hills	Pliocene and Pleistocene gravels, sandstone	200-100
	Joban hills	Pliocene tuffaceous shale, Pleistocene gravels	150-50

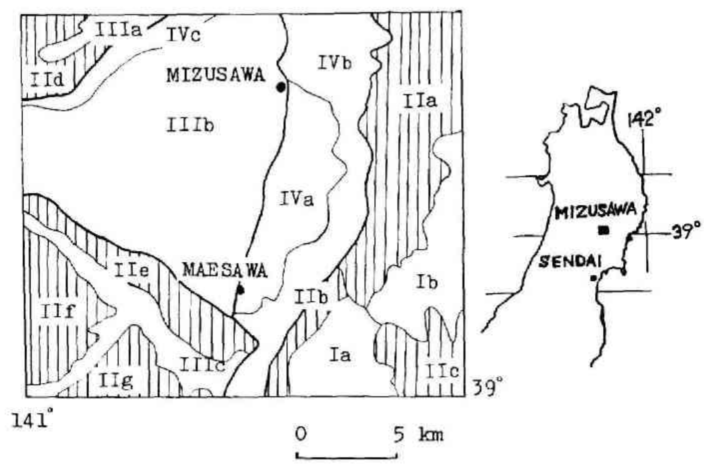

Fig. 1 Landform Division of the Mizusawa Quadrangle (Fujiwara, et al. 1963)

Isawa fan
- IIIb: Isawa upland
- IVc : Isawa lowland

Northern hills
- IId : Nagasaka hills
- IIIa: Nagasawa upland

Southern hills
- IIe : Kitamata hills
- IIf : Minamimata hills
- IIg : Koromogawa hills
- IIIc: Koromogawa upland

Western margin of the Kitakami mountains
- Ia : Tabashine mountains
- Ib : Omandate mountains
- IIa : Tashiro hills
- IIb : Western slope of Mt. Tabashine
- IIc : Yanomori hills

Lowland plain of the Kitakami river
- IVa : Anetai lowland
- IVb : Kitakami river lowland

The western hilly region is separated by the broad extension of Isawa fan and northern and southern sections are described in the following two paragraphs.

Isawa fan and the Kitakami valley plain occupying more than half of the area of the quadrangle are not discussed here.

2) Northern hilly section

Nagasaka hills recognized as a topographical unit area in Fig. 1 have an undulating feature with gradient about 20° at maximum, and are dissected by many small tributaries flowing onto the middle terrace 150–100 m high with few valleys ($15/km^2$) (Fig. 2). But the dissection of the hills has almost ceased since the stream of the Nagasawa river, a tributary to the Kitakami river, shifted southward and incised there, leaving the middle terrace. At present the erosion is regarded to be fossilized. Smoothening of hill slopes is in process, resulting in the undulating features.

Nagasaka hills have two-stepped erosion surfaces 240–220 m and 180–160 m in altitudes that cut the Tertiary formations. At the northern half, because of fossilized topography, undulation of the surfaces seems to be preserved for long. The southern section along the Isawa river is still affected by active lateral erosion of the river to maintain bluffs more than 50 m in height. In short, the locational conditions different between the northern half and the sourthern resulted in different dissection features of the hills. Thus here arose both the accordant elevations of the hill tops and the heterogeneous dissection features in both parts.

3) Southern hilly section

The hills have three sections separated by the Kitamata and the Minamimata valleys, which join to the Koromo river (Fig. 3), and have common characteristics in each section. High-level valleys (Nakamura 1969a), most of which are expressed as "gentle piedmont slope" on the topographical division map (Fujiwara, et al. 1963), are developed at 220–200 m in height, above the major knickpoints in many small tributaries. As are same in other regions, they are situated near the valley heads or adjacent to the divides.

Hill-top surfaces are 240–220 m and 180–160 m[1] in height, same as in the Nagasaka hills. Rather uniform features such as leveled tops, rounded divides, high-level valleys and almost fossilized erosion on the hill-top surfaces, and various dissection features along the present main tributaries are seen. Thus the hill morphology is formed not only in the past but even at the present. Tributaries to

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1) I. Akojima (1969) described these two levels as "upper Ishuzaka" and "lower Ishuzaka" surfaces which are remnants of river terraces. He called this hilly region as "Hiraizumi hills".

Fig. 2 Distribution of undulating area and rugged area, in the case of Nagasaka hills
(1) undulating area with *Muldental*
(2) rugged area with *Kerbtal* and *Sohlen-kerbtal*

to the Koromo river are so active in erosion that they cut steep scarps more than 50° in gradient at many places.

On hill slopes at the height of 160–140 m are the breaks in gradient, at which the undulating landforms above the breaks vary to steep cliffs cut by lateral erosion of tributaries.

4) Hilly sections along the western margin of Kitakami mountains

Mt. Tabashine (595.7 m) is a remnant of the lower peneplain of Kitakami mountains. Its west slopes are dissected a little and are skirted with colluvial

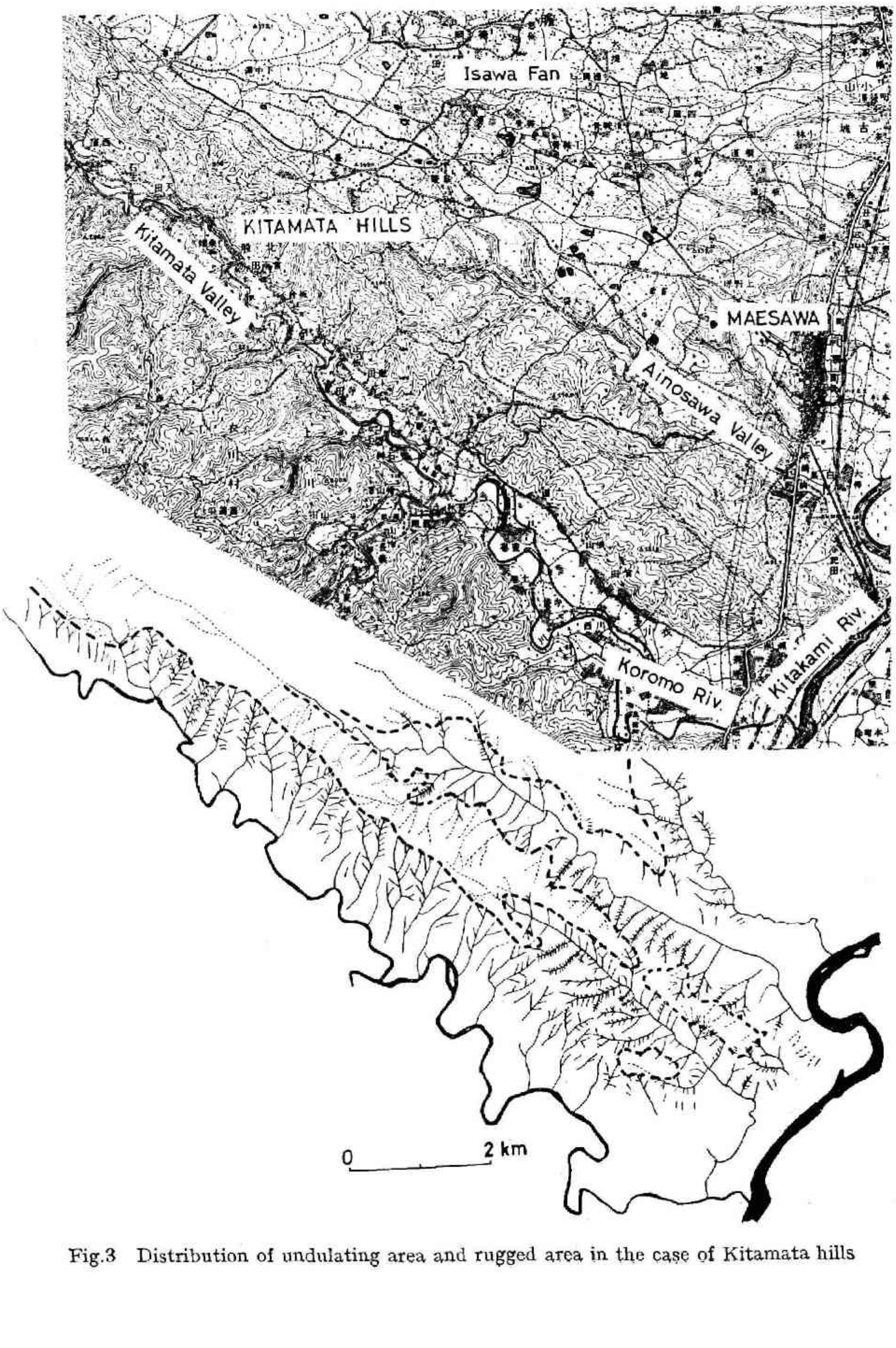

Fig.3 Distribution of undulating area and rugged area in the case of Kitamata hills

slopes. The east side is, on the contrary, dissected by many *Sohlen-kerbtäler* to make a rugged topography. On the flank of Mt. Tabashine two gentler slopes are recognized at the heights of 200–180 m and 140–130 m, which are accordant with the heights of erosion surfaces in Yanomori, and Tashiro sections.

Tashiro hills are densely dissected by valleys with various lengths in the north, and are roughly dissected in the south remaining as flat leveled surfaces. Lithological difference in the hills is reflected in the contrasting dissection features as follows. In the schalstein area hill-top level is preserved only at the height of 120 m, densely dissected,and in the siltstone area flat surfaces remain widely with few dissecting valleys. This seems to be an inverted relationship between expansion of dissection and resistibility of rocks, and it required some locational reasons explaining such evidences.

4 Some remarkable features in the hills

An asymmetrical feature on both sides of a divide is discussed here as an indicator of the complexity in hill morphology, and the reason why such asymmetrical feature has come is testified with the consideration on locational conditions.

1) Undulating area in the Nagasaka hills is relatively wide (Fig. 4a), and it is due to the fact that the active lateral erosion by the Isawa river has continually created fresh bluffs in front of the hills, i.e. the bluffs retreated by lateral erosion too fast to make *Kerbtal* develop on the bluffs. Another favorable condition for development of an undulating area is that the main divide runs parallel to the Isawa river, which prevented the undulating area from the *Kerbtal* encroachment adjusting to the drainage basin of the Isawa river.

2) In the Kitamata and the Minamimata hills, undulating areas are confined to the crest of main ridges and near the heads of high-level valleys (Fig. 4b), and rugged areas are surrounding. The southwestern slope of the Kitamata hills, where the 160 m surface can be restored, has had a well developed drainage system before the recent rejuvenation began. Consequently the head erosion of each tributary expanded the rugged area, increasing relief between 160 m surface and valley floors of the tributaries (Fig. 4b).

3) The northeastern slope of the Kitamata hills, where the Ainosawa valley, a tributary to the Kitakami river, has a course parallel to the main divide, has 120 m terrace at its midslope. The terrace is correlated to the Uenohara surface (the upper terrace, Fujiwara, et. al. 1963), and is separated by the Ainosawa valley from the Isawa elevated fan. At present the terrace is defending the divide against the active linear erosion by the Ainosawa valley. In order to enlarge the rugged area, the 120 m terrace must be dissected by *Kerbtäler* at first, but the

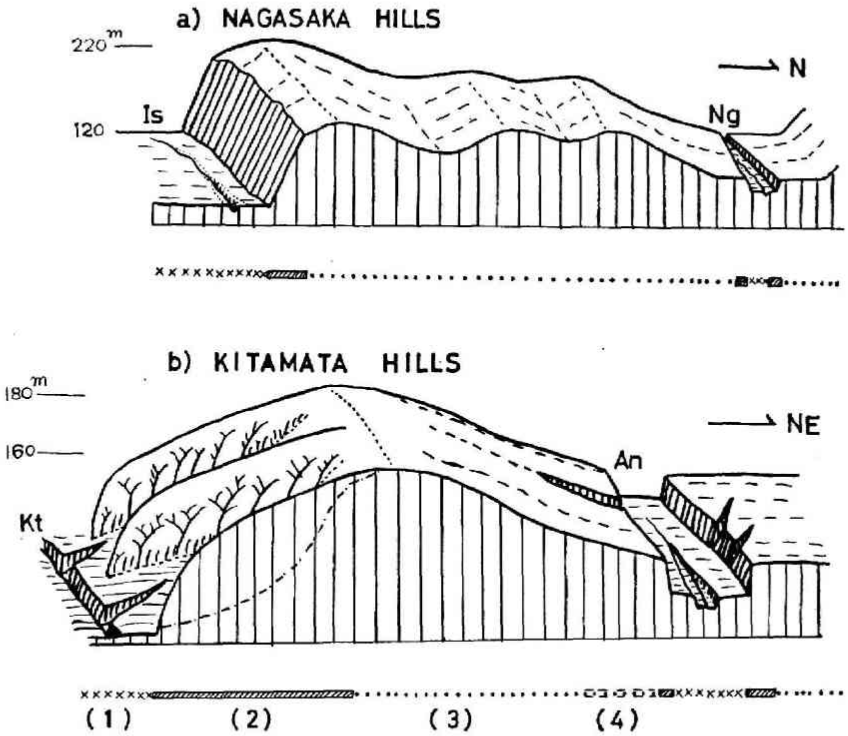

Fig. 4 Diagram illustrating the distribution pattern of two areas
(1) valley plain or flat terrace surface
(2) rugged area with *Kerbtal* and *Sohlen-kerbtal*
(3) undulating area with *Muldental*
(4) undulating but partly dissected area
Is: the Isawa valley Ng: the Nagasawa valley
Kt: the Kitamata valley An: the Ainosawa valley

terrace did not suffer such dissection[2], therefore this terrace has a function to sustain the undulating area in this section.

On the other hand, 160 m surface along the Kitamata valley, to the southwest of the main divide of the Kitamata hills, did not make defence against vigorous head erosion and introduced the rapid rejuvenation. It is reasonable to deduce that on the 160 m surface an undulating landform had developed and after certain uplift the *Muldentäler* had easily accepted a rapid rejuvenation according to the antecedent drainage system on the left side of the Kitamata valley.

2) When the terrace is almost entirely flat, dissecting valley (*Kerbtal*) can not develop rapidly because *Kerbtal* develops at the trough of undulation on the terrace surface.

5 Three types of variation in relative location of the rugged and undulating features

Three types of relationship between the rugged area and the undulating area in the hills are shown in Fig. 5.

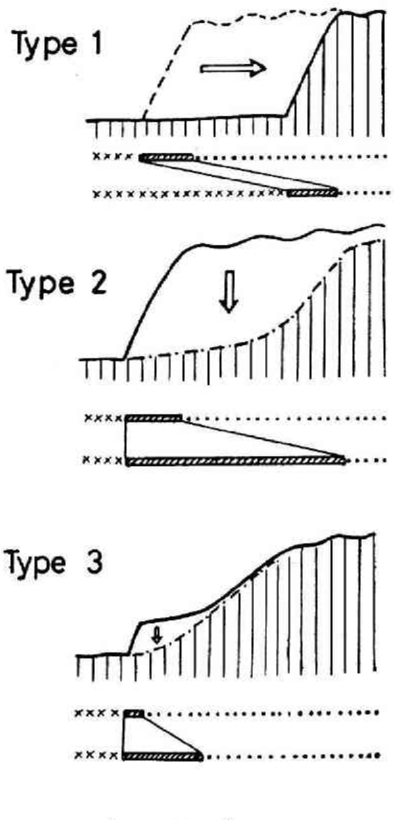

Fig. 5 Movement and enlargement of rugged area
1: undulating area
2: rugged area
3: valley plain or flat terrace surface

1) Shifting as well as forward movement of rugged area occurs at the cost of undulating area (Type 1), but the unsuffered area is still undulating unless it is captured by this shifting front. And the area where the front of rugged area has passed through becomes to start as a new-born flat surface which must be settled as a part of another undulating area.

2) Expansion of a rugged area is promoted by the head erosion of many tributaries, and the undulating area is reduced and separated into narrow segments of the initial surface (Type 2). This case is observed along the Kitamata valley, to the southwest of the main divide of the Kitamata hills.

3) The third type is found at the eastern margin of the Isawa elevated fan, where the fan surface is being undercut at the rim by the dissection and lateral shifting of small valleys leaving rugged features (Type 3).

The terraces between the hill slopes and the valley plains work as a buffer for the hills against the linear erosion by the stream in the valley plain.

In the western slope of Mt. Tabashine, the Yanomori, and the Tashiro hills, the dissection patterns are similar to those in the above mentioned areas, but are of smaller scale and more intricated. Undulating areas are distributed near the finely branched and rounded divides where linear erosion can reach no more because of the lack of water concentration.

6 Conclusion

1) The actural state of coexistence of undulating and rugged areas in the hilly region is affected by the relative position of the draining systems to the divide at the time of formation of the drainage system.

2) There are three types of movement or enlargement of rugged areas; advance in place of retreat of undulating areas, expansion by head erosion, and construction by undercutting of streams.

3) The presence of the intermediate surface has an effect that the surface or terrace releaves the action of undercutting and lateral erosion, and then saves the grade of actualization of several geomorphic conditions.

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